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Monetary Analysis:

A VAR perspective

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Abstract

The purpose of this study is to investigate the dynamic relationships between some key variables for the euro area by means of a systems approach (i.e. so-called Vector Autoregression) and to simulate their responses with respect to monetary policy shocks. The main result is that rather simple models can provide plausible reactions to changes in monetary policy. In particular, a positive shock in the short-term nominal interest rate is followed by a transitory decline in real income as well as a negative and permanent effect on the price level and nominal M3, leaving real M3 broadly unchanged.

Key words: Monetary analysis, VAR models, generalized impulse response functions

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Content

1. Introduction

The ultimately monetary nature of inflation − i.e. the fact that prolonged periods of high inflation are associated with high monetary growth − is essentially undisputed in academic and central banking circles. While other factors (such as variations in aggregate demand or technological changes) can influence price developments at shorter horizons, this does not negate the underlying long-term relationship between prices and the money stock. As a consequence, this key relationship has also called for the assignment of a prominent role to money in the ECB's monetary policy strategy.

In addressing the challenge of separating medium- to longer-term risks from shorter-term *"noises"*, a number of tools have been used. Besides a regular analysis of excess liquidity measures and the analysis of monetary variables in conjunction with variables from the real side of the economy, a thorough investigation of the components and counterparts of M3 is carried out on a regular basis by the ECB staff.

In fact, the relationship between interest rates, money, its components and counterparts, real income and, ultimately, prices forms an integral part of the transmission mechanism and, therefore, stands at the heart of monetary policy analysis. The dynamics, strength and timing of the effects of changes in policy interest rates on these variables are key questions for any central bank. When trying to quantify these effects, various econometric methods have been used, including Vector Autoregressive models (VAR models), small structural models and large macro-econometric models. This study focuses on presenting quantitative evidence on the interplay between interest rates, money, its components and counterparts, real GDP and prices in the euro area by making use of such VAR models. More specifically, the purpose is to trace out the historical relationships that have prevailed in the last two and a half decades in euro area data.

2. VAR models and monetary policy

VAR models have become very popular in empirical economics and also in the analysis of monetary policy effects.[1] The general representation of such type of model is as follows:

$$(1) \qquad Y_t = A + BY_{t-1} + C(L)X_t + \varepsilon_t$$

[1] For a more detailed description, see Sims (1980).

where Y_t represents a vector of several (euro area) variables measured over the same sample period ($t = 1, .., T$), A is a vector of absolute terms, B is a vector of coefficients, C is a vector of exogenous variables and ε_t is a vector of error terms. The vector X is included to allow for a contemporaneous influence of exogenous variables such as, for instance, oil prices. The specification implicitly assumes that there is no feedback from the euro area to the exogenous variables. In line with these considerations, a standard VAR model widely used in the literature would read as follows:

$$(2) \qquad Y_t = A + BY_{t-1} + C(L)X_t + \varepsilon_t$$

$$(3) \qquad Y'_t = \begin{bmatrix} s_t & yr_t & p_t \end{bmatrix}$$

$$(4) \qquad X'_t = \begin{bmatrix} oilp_t \end{bmatrix}$$

where *s* stands for a short-term interest rate, *p*, *yr* and *oilp* stand for a consumer price index, real GDP and the oil price, respectively. The small letters – with the exception of the interest rate - denote logarithms. In such a framework, monetary policy effects have often been described in terms of reactions of the other variables in the system to an unexpected rise (i.e. a "*shock*") in short-term interest rates. Given that the VAR system attempts to mirror the historical behaviour of the data, a contractionary monetary policy shock is then defined as a positive deviation of the interest rate from the estimated average reaction function of the central bank for the sample period.[2]

The dynamic response pattern of the reactions of the other variables to a shock are then often illustrated in terms of the so-called "*impulse response functions*". The basic reason why the impulse response analysis of the effects of monetary policy focuses on the impact of the unsystematic shock to short-term interest rates is that this approach addresses the so-called "*identification problem*". In essence, the transmission mechanism describes how a change in monetary policy affects other macroeconomic variables (in particular, prices), other things being equal. If monetary policy changes because of a shock to output or prices (as emphasized, for instance, in the so-called "*Taylor rules*" literature), it is not always possible to separate the impact of monetary policy on other variables from the impact of the initial shock. Only the unsystematic part of monetary policy is (by definition) identified separately from developments in other variables and thus allows the transmission mechanism itself to be traced out.

[2] It should be noted, however, that the concept of a reaction function used should not be interpreted in a structural sense. VAR models are by their very nature "reduced-form models"; therefore, the interest rate equation rather represents the derived reaction of the central bank within the system applied.

3. Analysis of the behaviour of M3 components

As a first step, we try to closely investigate the behaviour of the components of M3 for the euro area. The corresponding system thus includes as key variables the HICP index, real GDP, nominal M3, nominal M1, a long-term and a short-term nominal interest rate. In addition, a linear trend[3], a commodity price index[2] [4]and an oil price index are used as exogenous explanatory variables.

The linear trend allows trend long-term growth and the prolonged disinflation over the sample to be controlled for. Since the focus of this study is on the long-run relationships between the variables, a VAR in levels is estimated and solved for its dynamic responses.[5] As is quite common in the literature, the three-month market interest rate is chosen as the policy variable.

Chart 1 below then illustrates the reaction of all variables in response to a transitory (i.e. one-off) shock in the interest rate by one standard deviation and the respective 65% confidence interval.[6] The reactions of the variables included in the system are then shown for a time horizon of 24 quarters.

Expressed in non-technical terms, the exercise described above is reflected in an upward movement in the interest rate response by one standard deviation. The subsequent movements in the selected variables are then endogenous, which means that they are caused by the reactions of the variables in the system and the lagged values of the interest rate. By the same line of reasoning, all other variables start from the zero line, reflecting the fact that, in the first quarter, there are no deviations from the baseline since these variables are not shocked by definition.

Against this background, it is also worth mentioning that this study differs from an earlier study of Peersman and Smets (2003) − which contains a number of interesting results − for three main reasons. First and foremost, in our exercise we concentrate deliberately on the monetary analysis aspects in the VAR. Second, we make use of generalised impulse responne

[3] In a technical sense, the reason for introducing the trend variable is the problem of "*spurious correlation*". This expression describes the fact that economic time series often tend to move in the same direction, reflecting a similar upward or downward trend. A simple regression of the variables may thus not reflect the true association: it may simply reflect the common trend present in them. One way of avoiding such "*spurious correlation*" is the introduction of a linear time trend into the model. Another way would be to explicitly "*de-trend*" the variables and run the regression on the de-trended variables.

[4] As emphasised by Sims for the case of the US, the use of a commodity price index as a leading indicator for domestic inflation in the policy reaction function eliminates the positive response of prices to a contractionary monetary policy shock. See Sims (1992) for more details.

[5] More specifically, the impulse response analysis is carried out using generalized impulse response functions. The purpose of generalized impulse response functions to circumvent the problem of the dependence of the orthogonalized impulse responses on the ordering of the variables in the VAR. See Pesaran and Shin (1998) for details.

[6] If the usual 95% confidence interval is used, the price reaction is not significant. This is not uncommon in the literature and can be attributed to the random walk behaviour of prices. Most authors react by choosing a narrower confidence interval. We follow Bagliano and Favero (1999) who also use one standard deviation (corresponding to 65% bands).

functions which helps us to circumvent the issues related to the so-called "*ordering problem*". Third, although somewhat less important, we use a longer sample.

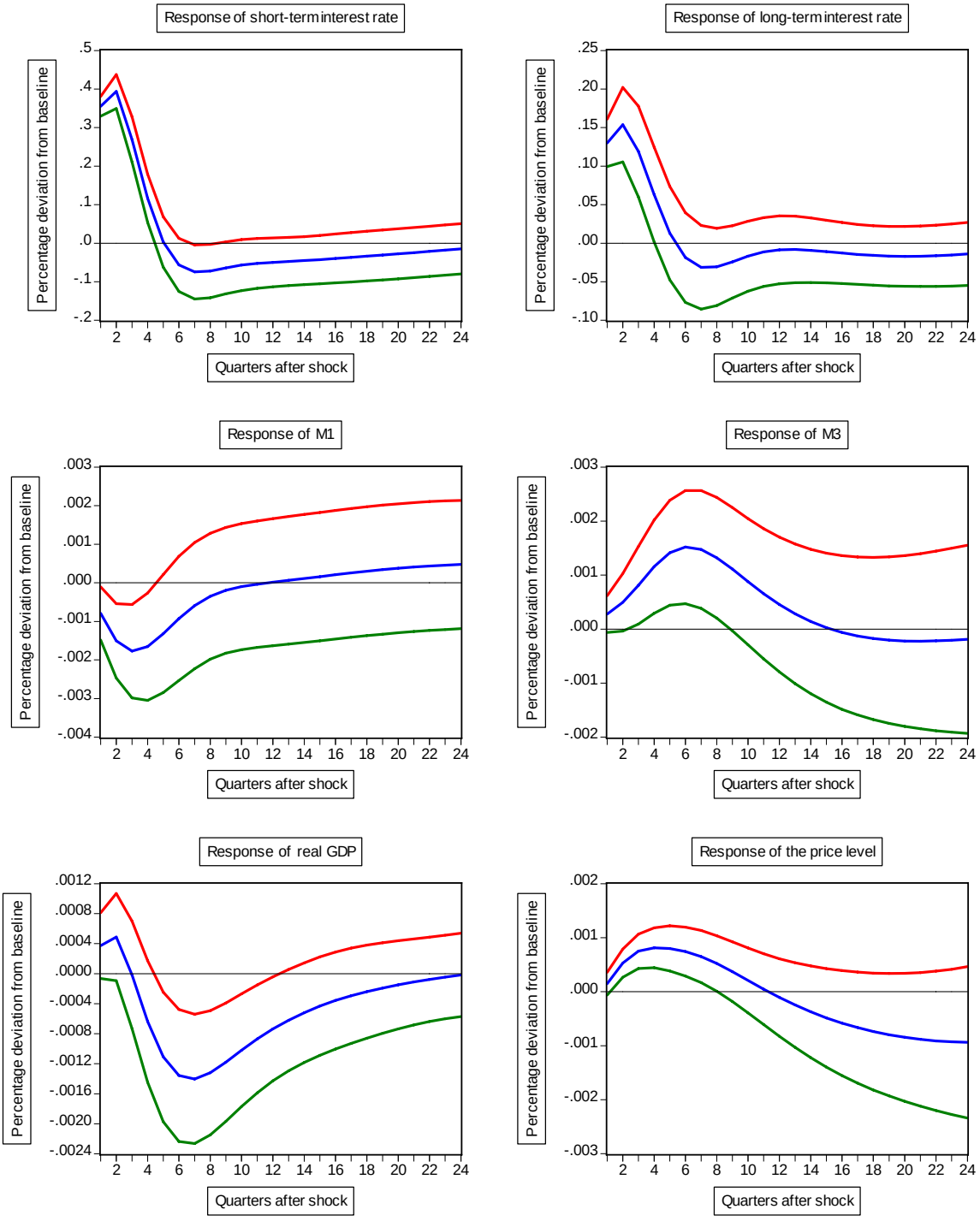
According to the results, the increase in the short-term interest rate is accompanied by a similar, albeit smaller, increase in the long-term interest rate (see Chart 1). This finding is clearly in line with the so-called *"expectations hypothesis"* of the term structure of the interest rates. Furthermore, a transitory rise in interest rates leads to an immediate decline in real income, reaching its trough after six quarters. After twenty-four quarters, however, the effect seems to have faded away, thus supporting the evidence of the long-run neutrality of money. Moreover, the rise in the short-term interest rate is followed by a notable decline in the HICP and, to a lesser extent, in the broad monetary aggregate M3. This decline starts to materialize approximately after ten quarters. With respect to the latter finding, it is particularly worth noting that both variables display an immediate rise, a phenomenon that is well-known in the literature as the "*price puzzle*".

It is interesting to see, however, that, while M3 seems to react in a more sluggish way, euro area M1 seems to react rather immediately and in a strongly negative way to the interest rate shock. Quite obviously, the slow response of M3 is clearly due to the initial increase in the other components of M3. An interest rate tightening gives rise to substitution effects from monetary components that bear no or regulated interest into time deposits and money market funds that are also included in the broad monetary aggregates. This finding is consistent with the literature on money demand.[7]

In sum, the findings are in line with theoretical considerations stating that changes in interest rates will have no long-run effects on real economic variables, such as real output.

[7] See Stracca (2001), Brand and Cassola (2000), Calza; Gerdesmeier and Levy (2001), Coenen and Vega (2001), Bruggeman, Donati and Warne (2003).

Chart 1: Impulse response functions following a transitory increase in the short-term interest rate by one standard deviation



Note: Sample period 1980 Q1- 2006 Q4.

4. Analysis of the behaviour of M3 counterparts

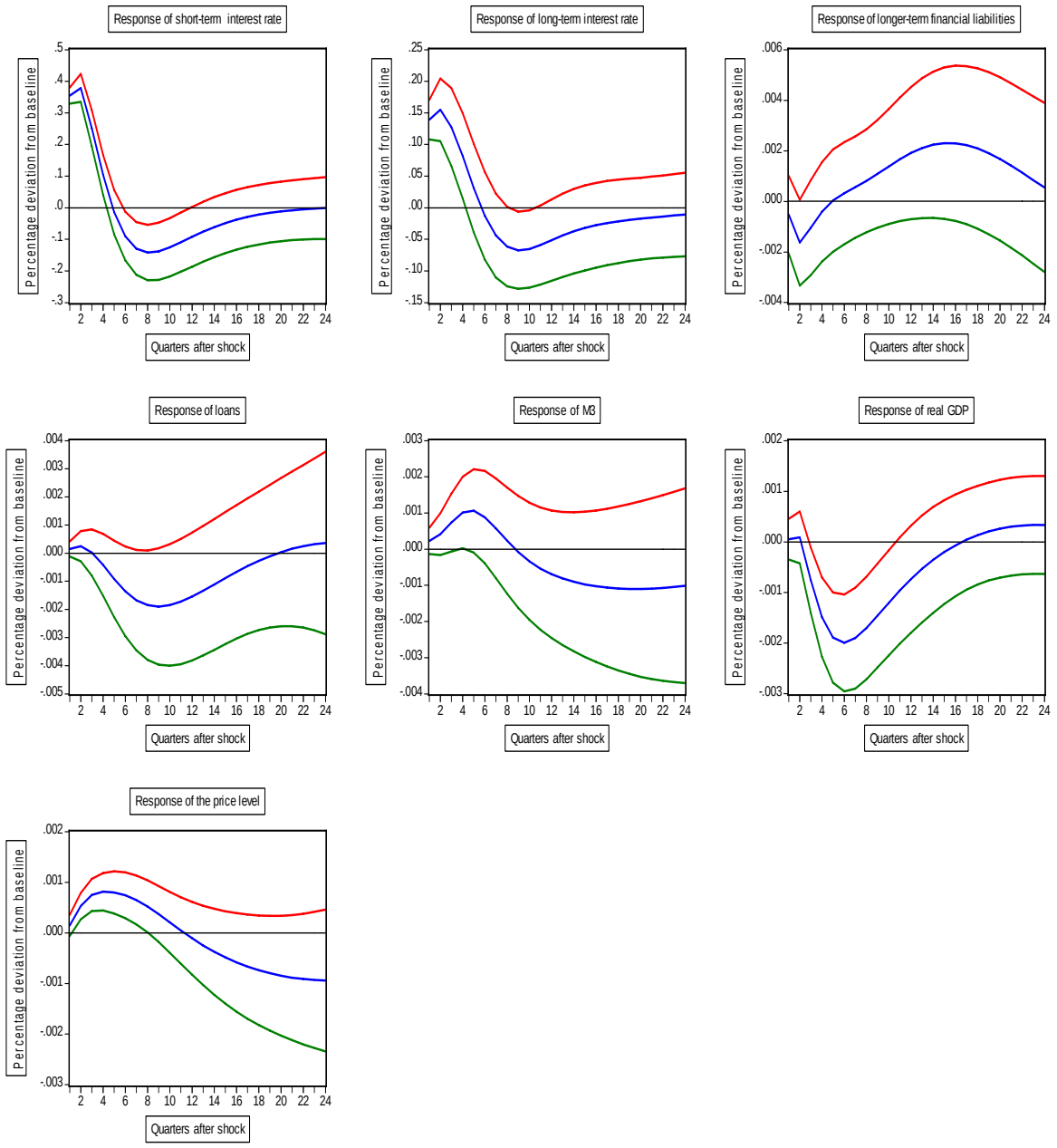
We now turn our attention to a closer investigation of the counterparts of M3. The corresponding system includes as key variables the HICP index, real GDP, nominal M3, nominal MFI loans to the private sector, MFI longer-term financial liabilities, a long-term and a short-term nominal interest rate.[8] As before, in addition, a linear trend, a commodity price index and an oil price index were used as exogenous explanatory variables, as it was the case in the VAR model used in the previous section.

Chart 2 below illustrates the responses of the variables in the system to a transitory (i.e. one-off) shock in the interest rate by one standard deviation and the respective 65% confidence interval. The reactions of the variables included in the system are again shown for a time horizon of twenty-four quarters.

As in the case of the components' analysis, also the analysis of the counterparts seems to confirm the presence of a kind of *"expectations hypothesis"*-effect of the term structure of interest rates in the data. Moreover, a transitory decline in real income, and a permanent decline in euro area prices and M3. At the same time, MFI loans to the private sector soon start to decline while MFI longer-term financial liabilities slowly start to increase after around six quarters, reaching a peak after roughly sixteen quarters and then start to decline

[8] It is worth noting that in the exercise related to the counterparts of M3, the net external asset position of MFIs is not included as a separate variable. This is justified in order to avoid perfect multicollinearity. Therefore, the reactions shown in the analysis do not explicitly capture the influence of this variable.

Chart 2: Impulse response functions following a transitory increase in the short-term interest rate by one standard deviation



Note: Sample period 1980 Q1 - 2006 Q4.

5. Summary and conclusions

The purpose of the study has been to investigate more closely the dynamic relationships between some key variables for the euro area. More specifically, two small models (one trying to capture the components' side of euro area M3 and one trying to capture the counterparts' side of euro area M3) are estimated by means of a VAR approach and simulated for their responses with respect to a monetary policy shock.

The main result is that these rather simple models can provide a reasonable description of the reactions of economic variables to changes in monetary policy. In particular, a positive shock in the short-term nominal interest rate is followed by a *transitory* decline in real income and loans, a *transitory* increase in MFI longer-term financial liabilities as well as a negative and *permanent* effect on the price level and nominal M3. Further work will need to focus on a further refinement of these results by imposing structural relationships and comparing them to the result reported here. Moreover, robustness tests will have to be carried out. Finally, the analysis might also focus on the inclusion of a more detailed breakdown of the instruments included in the components and counterparts of M3.

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